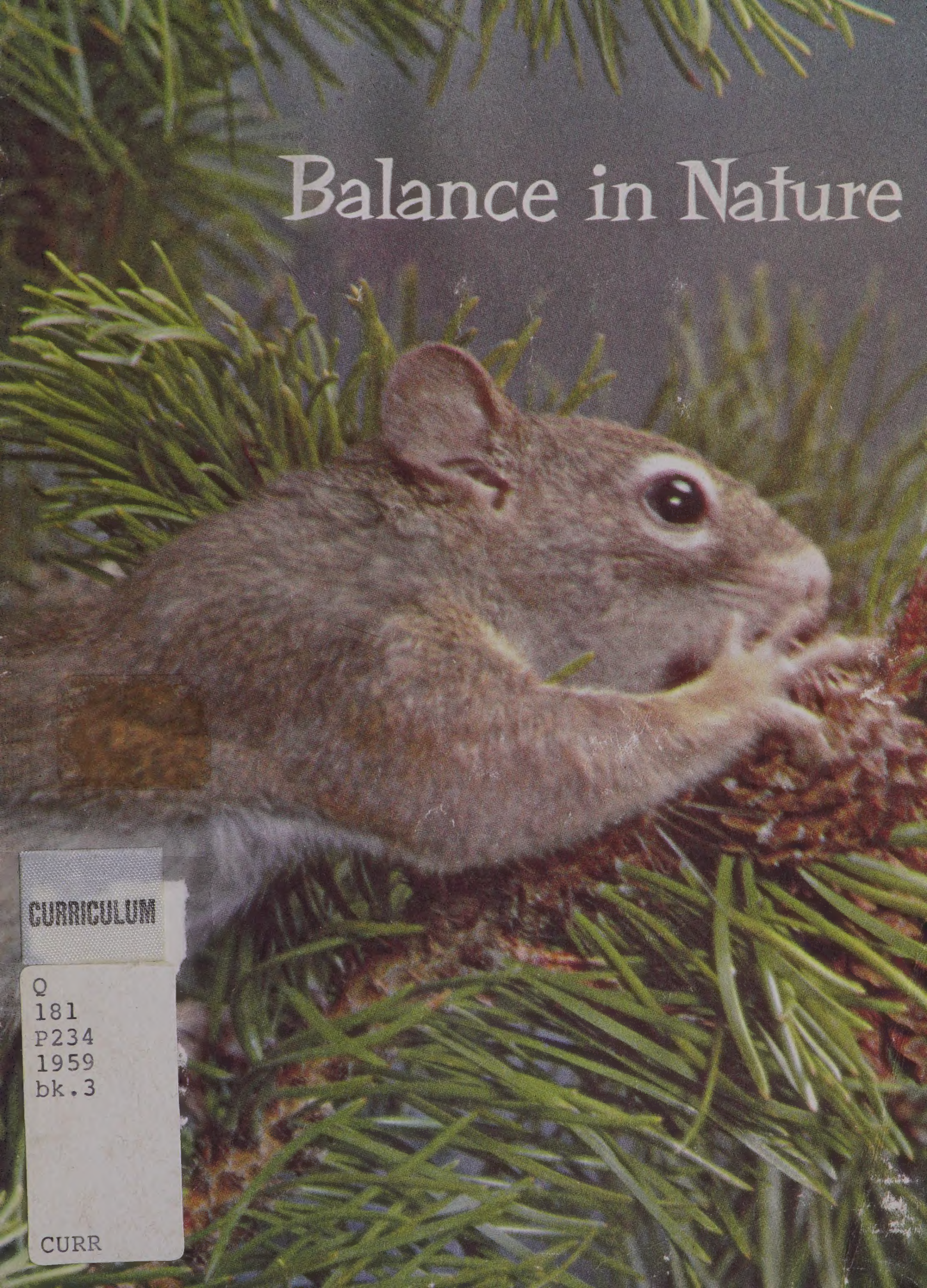
Balance in Nature



Redrawn and simplified from R. Buchsbaum's Readings in Ecology.

THE BASIC SCIENCE EDUCATION SERIES

Balance in Nature

Junior High

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Balance in Nature

ONE spring Farmer Brown had an unusually good field of wheat. Whenever he saw any birds in this field, he got his gun and shot as many of the birds as he could. In the middle of the summer he found that his wheat was being ruined by insects. With no birds to feed on them, the insects had multiplied very fast. What Farmer Brown did not understand was this: A bird is not simply an animal which eats food that the farmer may want for himself. Instead, it is one of many links in the complex surroundings, or *environment,* in which we live.

How much grain a farmer can raise on an acre of ground depends on many factors. All of these factors can be divided into two big groups. Such things as the richness of the soil, the amount of rainfall, the amount of sunlight, and the temperature belong together in one of these groups. This group may be called *nonliving factors.* The second group may be called *living factors.* The living factors in any plant's environment are animals and other plants. Wheat, for example, may be damaged by wheat rust, a tiny plant that feeds on wheat; or it may be eaten up by plant-eating animals such as birds or grasshoppers.

The nonliving and the living factors in the environment of such a plant as wheat are closely woven together. If the winter is colder than usual, few grasshoppers will hatch in the spring and there will not be much danger that grasshoppers will eat up the wheat. A cold winter may kill grasshoppers, but it may also force certain birds which usually feed on grasshoppers to eat valuable crops instead. And so it goes. It is easy to see that the relations of plants and animals to their environment are very complex, and that any change in the environment is likely to bring about a whole series of changes.

Courtesy J. I. Case Co.


Erosion Charles Phelps Cushing

If a region is left to itself, the numbers of all the different living things in the region are likely to stay roughly about the same, year after year. There tends to be a balance among all the plants and animals of the region. Such a balance is often spoken of as *balance in nature*. If anything happens to bring about serious changes in the plant and animal populations of a region, we say that the balance in nature is upset or that there is *unbalance*.

In recent years much has been written and said about the harm man has done by disturbing his environment. We know that the cutting of timber off certain lands has helped cause the wearing away of valuable soils. We know that overhunting killed off the passenger pigeon—a bird that once occurred in huge flocks. We know that draining swamps helps do away with mosquitoes but also does away with birds that eat insects which may be worse than mosquitoes. Not many people, however, understand that simply planting a large field of wheat upsets the balance in nature. The farmer clears away all the trees, shrubs, ferns, flowers, and mosses that would naturally grow in the field. He drives away most of the animals which would naturally live there. He raises many acres of a single kind of plant. When he does so, he makes conditions excellent for insects that feed on wheat. They are likely to multiply so fast that they become serious pests.

Man is always trying to make his surroundings fit him rather than to make himself fit into his surroundings. He is forever changing the face of the earth. He is forever causing trouble for himself by upsetting the balance in nature and is always hunting for ways of undoing the harm he has done. It is important, then, that everyone should understand as much as possible about balance in nature.

Arctic Tundra *Acme* Tropical Rain Forest *Ewing Galloway*

The Earth's Plants and Animals

All of us know that the earth is not a haphazard jumble of hot and cold places or a disorderly mixture of all kinds of plants and animals. If someone mentions northern Canada, we have a picture in our minds of a rather barren region with much snow and ice. We do not ask about the size of the banana crop or about the danger of being killed by a lion. In the same way, when someone mentions a tropical rain forest, we think of warmth and moisture, of many trees, and of elephants and monkeys. We do not think of polar bears.

No plant or animal is so made that it can live in all the many climates to be found in the world. In fact, the limits within which a plant or animal can live are in many cases very narrow.

The earth at the two poles is covered with ice and snow. From each pole toward the Equator there is a gradual increase in temperature and in amount of sunlight. If we begin at either pole and travel toward the Equator, we first find tundras, regions where the plants are small and sparse. Tundras give way to evergreen forests. Evergreen forests give way to forests of broad-leaved trees, such as elms, oaks, and maples, which shed their leaves in winter. At last we come to the tropical rain forests, or jungles.

Naturally there are variations within these regions that have been mentioned. Traveling east from Chicago, we would see forests of broad-leaved trees all the way to the Atlantic Ocean except, of course, where the trees have been cut away to make room for farms and towns. Going west from Chicago, we would cross prairies, then great plains, then deserts and mountains, and would finally end our journey in evergreen forests on the west coast. The differences we would find are related chiefly to the amount of rainfall.

Within any particular region there are differences related to such things as altitude and type of soil. Thus we can go on breaking up the surface of the earth into smaller and smaller units. In the Chicago region there are prairies, oak woods, beech and maple woods, pine woods, groves of poplars, and sandy beaches. Each of these has its own set of plants and animals. These plants and animals are not simply living in the same spot. Instead, they are bound together into a *plant-animal community.*

To help us understand what a plant-animal community is, let us examine briefly a community of people—a community made up of a small village and its surrounding farm country. The farmers form the basic group in the community. They raise plants and animals and so supply food not only for themselves but also for all the people of the village. Among the people of the village are a doctor, a clergyman, and some teachers. They perform services for the farmers, for one another, and for the storekeepers and other people of the village. The storekeepers sell to the others of the community the products brought in by the farmers. They sell, too, machinery, hardware, and coal brought in from other places. In other words, the people of a community are not simply living in the same place—they all depend on one another in some way.

A Sandy Beach *James Sawders*

A community of people may be a large city; it may be only a handful of people in a clearing in the jungle. In the same way, a plant-animal community may be either large or small.

A single plant-animal community is usually named for the most important plant in the community. An oak-woods community gets its name from the oak trees in it. The oak trees are not only the largest plants in the community; they are also chiefly responsible for the other kinds of plants and the kinds of animals that live there. To get a better idea of plant-animal communities, let us take an imaginary trip to the famous sand-dune region at the south end of Lake Michigan.

We arrive at the shore of the lake on a hot, windy day. The blazing sun has made the beach so hot and dry that it is almost unbearable. There are no trees to shade us from the sun or protect us from the wind. The only animals we see are a few flies which hover over but seldom rest on the hot sand.

Soon we walk away from the lake through an area covered with grass and find shelter under some cottonwood trees. Here it is more comfortable, and we notice some ants, birds, and spiders.

We soon decide that the protection of the cottonwoods is not enough, and we climb over a low dune into a pine forest. Here it is more shady. We see several kinds of animals in the pine trees and on the ground. The ground is covered with a thin layer of soil made up mostly of rotting pine needles.

Walking still farther away from the lake, we finally enter an oak woods. Here there is still more shade, it is much cooler and more moist, and we no longer notice the wind. There are many plants growing on the floor of the forest. They furnish food and shelter for many kinds of animals.

Beyond the oak woods we find a beech and maple woods. Here it is so cool and shady that we forget that a blazing sun is beating down

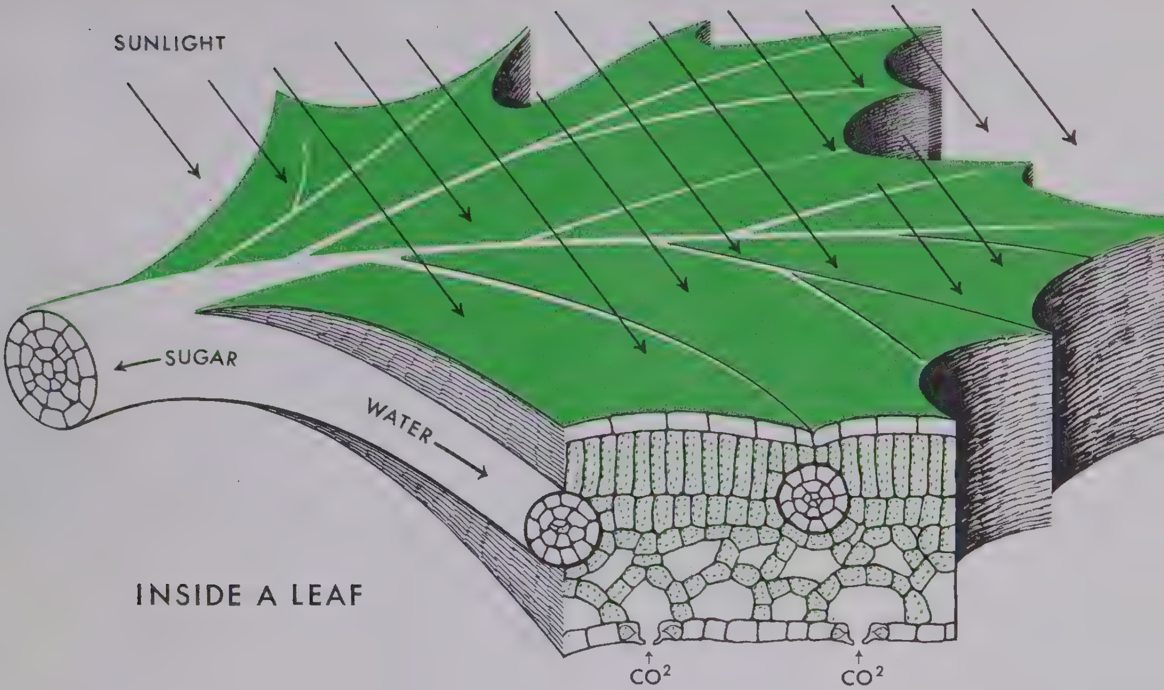
Maple-Beech Forest *Courtesy Ralph Buchsbaum*

on the tops of the trees. The air in the forest is moist and very still. We cannot feel the slightest breeze. On the forest floor we see mushrooms, ferns, snails, and frogs—plants and animals that could not possibly live on the sandy beach only a short distance away. We wait in the forest until evening. The forest grows very dark, but the temperature changes very little.

Now if we go back to the beach, we find that with the setting of the sun the beach has become too cool for comfort. The beach and the maple-beech forest are only a few miles apart and have the same natural climate. But the forest has a climate of its own which permits certain plants and animals to live there which could not possibly live on the beach. If the trees of the forest were cut down, the forest floor would soon be much like the beach. The trees of the forest not only tone down the natural climate but also furnish shelters where animals may hide themselves and their eggs and young from their enemies. But more important than toned-down climate and shelter in tying the plants and animals of a community together is food supply.

The basic problem of all living things is how to get enough food of the right kind. In communities of civilized people the importance of food-getting is often lost sight of. Millions of people never catch or raise their own food. They get it in exchange for such work as making steel rails or building houses or filling teeth or singing. There is, as we say, division of labor.

In plant-animal communities there is very little division of labor. The rule is, "Every man for himself." Therefore, finding out what an animal eats goes a long way toward finding out an animal's place in the community. Of course, animals do other things besides finding and eating food. They build shelters, sleep, mate, care for their young, and even play. But their feeding habits influence their other habits so strongly that simply by knowing who eats what in a community we get a fairly good idea of the community.



INSIDE A LEAF

Food-Chains

If there were no green plants on the earth, there could be no animals. Neither could there be any such plants as toadstools and molds, plants that are not green. No animals and practically no plants that are not green would have the food they need if it were not for green plants. Green plants can make their own food. No animals and almost no colorless plants can. Without food living things would not have energy for their bodily activities.

As the first step in food-making, green plants make sugar from water and carbon dioxide, one of the gases in the air. The energy they must have in order to do so comes from sunlight. Scientists call the manufacture of sugar in green plants *photosynthesis*. "Photosynthesis" means "putting together by means of light." In green plants with leaves, the leaves are the chief food factories.

In photosynthesis some of the energy of the sunlight is "locked up" in the sugar made. It is there to be used later by the plant that made the sugar, by some animal, or by some plant that cannot make food for itself.

As you see, then, all animals and all colorless plants except a very, very few depend on green plants for food and energy. Green plants are the basic group in every plant-animal community.

Most animals get the food they need by eating plants. These plant-eaters may be as small as flies or as large as elephants. They are called *herbivores*. The herbivores may be said to get energy from the sun at second hand, since they get it directly from the green plants that get it from the sun.

Many animals get the food they need by eating other animals. These meat-eaters are called *carnivores*. Most herbivores have carnivore enemies. Moreover, small carnivores are often eaten by larger carnivores and the larger carnivores by still large carnivores. The carnivores get their energy from the sun at third, fourth, or fifth hand.

Some animals eat both plants and animals. They are called *omnivores*. Man is one of them.

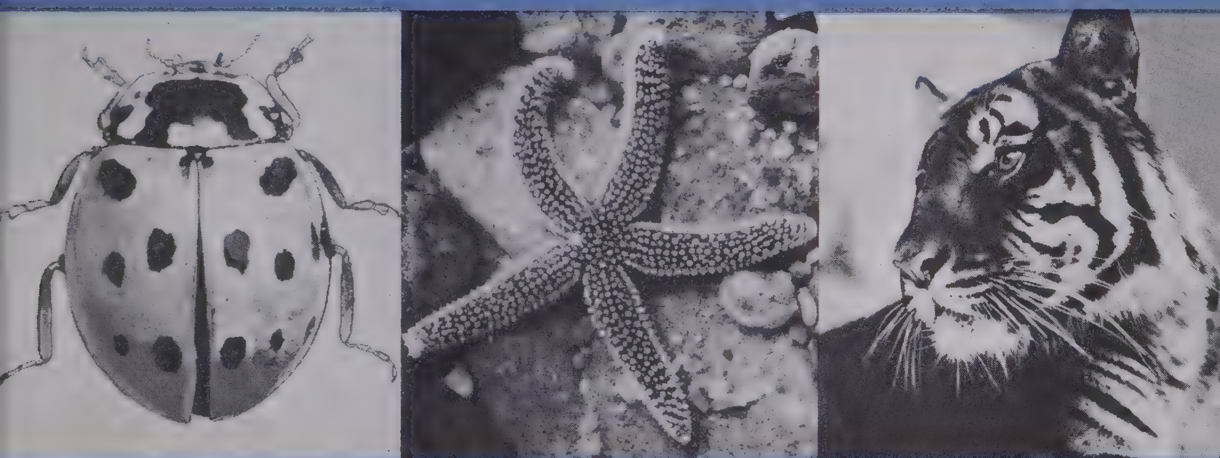
Man's food habits are different from those of most animals in two ways. Man eats a great variety of plants and animals, whereas most animals have a rather limited diet. Man, moreover, can eat food of any size, whereas other animals eat food of a fairly definite size range.

Some animals can feed on only one particular kind of plant or animal. Some can feed only on some special part of a plant or an animal. Butterflies, for example, feed only on nectar produced by flowers.

Probably in the beginning man could not eat food of all sizes. His diet was probably limited to such things as clams, oysters, fruits, and small mammals (animals with fur). As he learned to throw spears and use a bow and arrow, he found that he could kill animals much larger than himself. He found later that he could raise crops. Little seeds like wheat

Philip Gendreau — L. W. Brownell — George Rodger-Magnum

Herbivores: Cecropia Caterpillar, Squirrel, Elephant

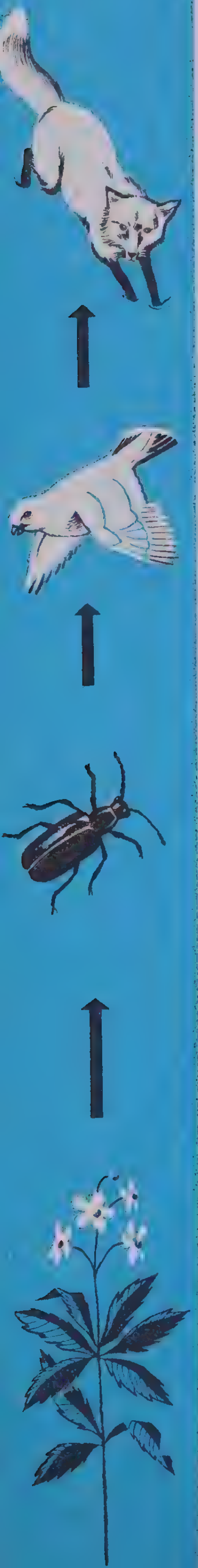


Ewing Galloway — Hugh Spencer — Philip Gendreau

Carnivores: Ladybird Beetle, Starfish, Tiger

Century Photos — Chace from Cushing — United Press

Omnivores: Robin, Black Bear, Man



seeds were not important when wheat plants were wild and not very numerous, but they became a good source of food when they could be raised in large quantities.

Of what size is the food that other animals can eat? A carnivore cannot eat an animal too big for it to catch. Spiders do not feed on rabbits, nor do swallows hunt foxes. On the other hand, the food of a carnivore cannot be so small that it is not worth hunting. Thus lions do not chase mice, and dogs do not feed on flies. A herbivore may eat plants much larger than itself. A caterpillar may eat the leaves of an oak tree, for example. The oak tree cannot run away or fight the caterpillar in any way!

The lower limit to the size of an animal's food depends largely upon the abundance of the food. As you have already been told, a large animal such as man can live on small seeds if he can get enough of them. Some whales eat nothing but very, very tiny plants and animals which occur in tremendous quantities at the surface of cold ocean waters. These whales are able to strain the tiny plants and animals out of the water. Foxes usually eat rabbits, but they may live on field mice if field mice are very abundant.

Since most animals eat only certain kinds and sizes of food, a plant-animal community can be broken down into separate *food-chains.* A food-chain is a series of living things directly linked to one another by what they eat. The first link in a food-chain is always a plant. Here is an example of a food-chain: In a pine woods the sap of the pine trees is sucked by tiny plant lice. The lice are eaten by spiders. Both lice and spiders are eaten by small birds. The small birds are preyed on by hawks. Since there is in the pine woods no animal that can catch a hawk, the hawk is called the *top carnivore,* the last link in the chain.

Few food-chains have more than five links. Five food-chains are pictured on these pages and on pages 14, 15, and 21. Notice that the longest of these chains has only five links.

The small plant-whale chain mentioned is as short as a chain can be. It has only two links.

The food-chains of sea, forest, or desert are all much alike. They almost all follow this general plan: plants to herbivores to small carnivores to large carnivores. In some cases a herbivore is the top animal in the chain. There are no carnivores, for example, large enough to depend on whales for food.

In general, each link in a food-chain is larger than the one before, but there are exceptions. You have already seen that herbivores may eat plants larger than themselves. Even some carnivores may eat animals larger than themselves. With the help of a poison some snakes can catch animals larger than themselves. Hunting in flocks is another way in which carnivores can catch animals larger than themselves. Wolves hunt in packs and catch deer twice the size of a wolf. Armies of ants have been known to kill young dogs.

As a rule there are many food-chains in a plant-animal community. The food-chains of a community overlap and connect at different points. All the food-chains of a community taken together are called a *food-web.*

Since a food-chain has only a few links, it is not hard to work out separate food-chains. One of the simplest ways is to examine the stomachs of animals that have been killed. But to trace all the food-chains in a community, even in a fairly small community, is far from easy. Food-webs have been thoroughly worked out for only a few places in the world—most of them where plant and animal life is rather sparse. The food-web shown on the front inside cover has been simplified from one worked out for an arctic island.

Food-Pyramids

So far nothing has been said about the numbers of the different plants and animals in a food-chain. Let us think first of the food-chain shown on this page. In a small part of the sea the number of one-celled plants floating about would run into billions. The number of tiny jointed-legged animals, or copepods, eating the plants would run into millions. The smelt eating these small animals would run into hundreds. There would be still fewer mackerel and only a few tuna.

Or let us take as another example the acorn-mice-owl chain. If we walked through an oak woods, we would probably see thousands of acorns on the ground. We probably would not see many mice, but if we were to set traps we would probably catch hundreds. In this same woods we would have to search very carefully to discover the few owls that live there.

To come to the point, the animals nearest the base of a food-chain are very abundant, the animals at the top rather scarce. It is not only the number of animals that decreases; it is also their total bulk, or weight. At each step in a food-chain some of the energy stored up by the plants at the base of the chain is used up. The higher up a chain one goes, the less energy there is to be had. The bulk of the animals at the top of the chain must be less than that of those farther down in the chain. Let us think of the grass-zebra-lion chain in Africa. The plants which a zebra eats weigh many times as much as the zebra itself. One lion eats about fifty zebras each year. Fifty zebras weigh much more than one lion.

Do you now see that, if a diagram of a food-chain were made that would give some idea of the numbers of the animals at each stage, the diagram would be a *pyramid* much like the one in the diagram on the inside back cover? At the base would be green plants. Above the plants would be the herbivores. Above them would be the carnivores, larger in size but fewer in number. On top of these there might be other carnivores, still larger in size and still smaller in number. And at the

Acorn—Mouse—Owl Food-Chain *Hugh Spencer, Philip Gendrea*

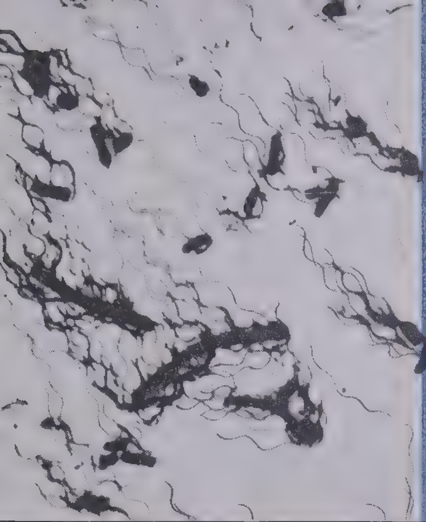
Grass—Zebra—Lion Food-Chain

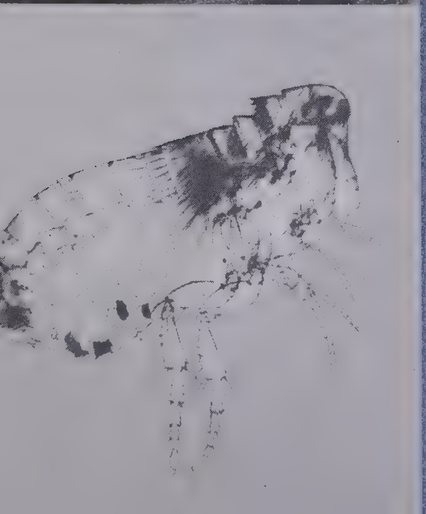
Ylla from Rapho-Guillumette

top there would be the top carnivore—a hawk, perhaps, or an owl, a lion, or a fish—very large in size but very small in number. Although there are no larger animals to eat them up, the top carnivores do not lead an easy life. They have to compete with others of their own kind for food, shelter, and mates, and with other kinds of carnivores for food.

Parasite-Chains

From what you have read about food-chains you probably think that the food story ends with the top carnivore—that this animal uses up the last bit of energy that was stored in the plants at the bottom of the chain. But the top carnivore is not the end point. The lion has no larger meat-eating enemies, but it has hundreds of smaller enemies. These are *parasites,* tiny plants or animals that live in or on the lion's body and get food from it. A lion may have ticks in its skin, tiny animals in its blood, and tapeworms in its intestines. Moths may lay eggs in its fur. When the eggs





hatch, the lion will become "moth-eaten." It may also have one or more diseases caused by tiny parasitic plants—diseases somewhat like the disease we call "athlete's foot."

Most people think of parasites as being less "respectable" than carnivores. We seldom read anything pleasant about parasites, but we often read about how "nobly" an eagle swoops down on its prey. And yet, who would not rather be robbed from time to time than killed? The parasite is a robber; the carnivore is a killer. The parasite takes bits of food from the plant or animal on which it is living—its *host*—or destroys bits of the host's body so slowly that often the host is able to repair the damage that is done. The carnivore kills its prey on the spot and eats its body. The two methods are different, but one is as "respectable" as the other.

Another wrong impression is that being a parasite is an unusual way of living. On the contrary, there are more animal parasites than there are herbivores and carnivores put together. Every herbivore and carnivore in the world is host to hundreds of tiny parasites.

Even parasites may have smaller parasites in their bodies. These smaller parasites may have still smaller parasites, and these still smaller ones. You see, then, that there may be *parasite-chains*. For example, a flea sucks the

Typhoid Bacteria, Parasite that Causes Disease

Cocoons of Insect Parasite on Caterpillar

Flea, Common Parasite of Furry Animals

Courtesy Biological Supply House

Hugh Spencer

Hugh Spencer

blood of a lion. In the flea's body there is a tiny worm which is a parasite. In the worm's body there is a one-celled animal. In this tiny animal there are tiny plant parasites—the kind we call bacteria. This parasite-chain is illustrated here.

An ordinary food-chain and a parasite-chain are different in this way: The links in an ordinary food-chain get larger in size and fewer in number; the links in a parasite-chain get smaller in size and greater in number. The pyramid is turned upside down.

An ordinary food-chain and a parasite-chain are alike in this way: The total bulk of living things gets less and less at each step. For example, the combined weight of all the fleas on a dog is only a small part of the dog's weight. Suppose for a moment that there were so many parasites on a host that they weighed more than their host. Then they would be sure to do so much harm to the host that the host would die and the parasites—at least most of them—would die too. To be successful, a parasite must get its food from its host without doing too much harm to the host.

Niches

Plant-animal communities differ greatly in the particular kinds of plants and animals living in them. They are all, however, very much alike in general organization. Each has its plants, its herbivores, its carnivores, and its parasites. Each has its *scavengers,* too—a group of animals that has not been mentioned before. Scavengers are animals that feed on the remains of dead animals or dead plants or both.

In various parts of the world there are great grasslands. Every grassland supports mice. The mice are of different kinds, but they all eat grass and have very much the same habits. Feeding upon the mice there are hawks and foxes. The grass, the mice, the hawks, and the foxes all follow a different way of life, but each has a definite role in the community. You might say that each one performs a definite "job." Each kind of job may be called a *niche.*

"Niche," then, means the place, or role, of an animal or plant in its community. To know exactly what the niche of any living thing is, one must know both about its food and about its enemies.

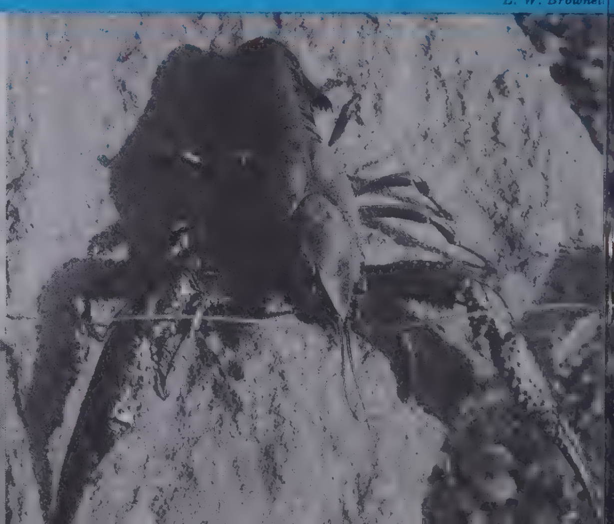
In the arctic regions the arctic fox feeds partly on the eggs of birds and the remains of seals killed by polar bears. In Africa the same niche—that of feeding on eggs and partly eaten dead animals—is filled by the hyena. The hyena eats ostrich eggs and the remains of zebras killed by lions. If we did not know about their food habits, we might not see any sort of parallel between a fox that lives among snow and ice and a hyena that lives in the hot plains of Africa. But, knowing of their food habits, we see that they perform the same job in their communities.

No matter on what continent we may be, if we enter a woods we are sure to find plant lice sucking sap. If, moreover, we know where to look, we are almost sure to find some kind of spider or ladybird beetle feeding on the plant lice. If there are caterpillars, there will be birds eating the caterpillars.

An odd niche is that filled by animals which pick ticks off other animals. In England the starling feeds on ticks from sheep and deer. In Africa the tickbird feeds on ticks from the skins of hoofed animals. In some of the islands of the Pacific there are land crabs that clean ticks off lizards.

In the ocean one of the most important niches of all is

Two Scavengers: King Vulture and Crayfish *Acme* *L. W. Brownell*



Hyena Ylla from Rapho-Guillumette

Arctic Fox American Museum of Natural History from Cushing

filled by the copepods. These little animals eat plants and animals too small to be seen without a microscope. The copepods use this food in growing into morsels large enough to be eaten by small fish. In many bodies of fresh water, water fleas fill this same niche.

One of the most important niches on land is that of the earthworms. Earthworms live in moist soil almost everywhere. They swallow soil and pass it through their digestive tracts. In the soil there is dead plant and animal material which furnishes food for the earthworms. As soil goes through an earthworm's digestive tract, it is ground very fine. Materials are mixed with it which help make the soil rich. The burrowing of the worms, moreover, aids soil drainage and helps air get into the soil. Without the work of the earthworms, the world as we know it today would not exist. Earthworms cannot live in dry soil. In the dry plains of our own Southwest ants take the place of earthworms and do a fairly good job of letting air into the soil. Ants do not swallow the soil, but they do a great deal of burrowing.

In the United States jack rabbits that eat grass have a definite niche. They are eaten by large carnivores. In South

J. C. Allen and Son

American Museum of Natural History

American Museum of Natural History

America there are no jack rabbits, but the same niche is filled by agoutis. In Africa it is filled by mouse deer or other animals of about the same size.

The idea of niches helps us understand any plant-animal community, no matter where the community is or how strange it may seem at first. It helps just as understanding one community of people helps us understand all other communities.

It takes almost twenty years for a child in America to prepare himself to take a real job in his community. In those years he learns to recognize plants, animals, streets, farms, and many, many other things that surround him. He learns to understand the happenings in the natural world about him. He learns to read, write, multiply, and tell time. He learns, too, about the organization of his community and about the niches filled by farmers, doctors, postmen, lawyers, and other workers in the community.

If an American goes to a small city in India, he will find what at first glance seems to be a totally different world. But will it take him another twenty years to understand the general workings of this new place? No. Probably it will take him more nearly twenty days. True, the climate may be different, the scenery, language, and costumes strange, and the plants almost entirely new. But there are still houses, streets, shops, wagons, trees, farmers, lawyers, doctors, and

Jack Rabbit
Agouti
Mouse Deer

policemen. Having learned the make-up of one community, he can understand almost any other.

Once we get used to the idea of niches, every animal and plant takes on a new meaning. Walking through a woods, we see a mouse scurrying across our path. The mouse is no longer just a mouse to us. It is a small herbivore that eats acorns and in turn is eaten by hawks and owls. A spider running up a tree trunk is not simply an eight-legged creature with unpleasant habits. Instead, it is a link in a food-chain—an animal that feeds on tiny plant lice and changes them into morsels of food large enough to be eaten by small birds.

Rhythms in Plant-Animal Communities

If you ever stay up during all of one night, you will surely notice many things going on that you have never seen or heard before. In your very house you may meet for the first time some busy mice that, all uninvited, have been sharing your roof and your food. You have not run into them before because they come out only at night when you are usually asleep. Across the street a night watchman walks slowly back and forth and probably has been doing so for years without attracting your attention. Down the street comes a curious truck with a big broom in front, and you get your first glimpse of the city's street sweeper. Close behind comes a bakery truck carrying bread to your corner grocery store. This nighttime community is very different from the daytime one of which you are a member. You are not a part of it at all. You are almost as well shut off from meeting the watchman and from being run over by the bakery truck as if you lived in another part of the world.

This same separation of day and night communities is to be found in nature. Let us look again at an oak woods. In the daytime the tree-plant lice-spider-small bird-hawk chain is in full swing. Butterflies suck the juices from flowers and are eaten by birds. At night most of these animals go to sleep, and other food-chains begin. For example, the birds which eat butterflies are replaced at night by bats which eat moths.

The day and night communities are not completely separated. Some animals come out at dusk and feed on both day and night animals. Some dragonflies are well fitted for feeding at dusk because they have compound eyes made up partly of small eyes good for seeing in bright light and partly of small eyes good for seeing in dim light. As a rule, earthworms come out of their burrows only at night and thus avoid the drying effects of the hot sun. In rainy weather, however, where there is no danger from drying, the worms may come out in the daytime.

In almost no regions are the day and night communities equal so far as number of animals is concerned. In some regions the day communities are larger than the night communities; in other regions the night communities are the larger.

In the regions near the poles the best season for animal life is summer. During part or all of the summer there is continuous daylight. As you might expect, almost all the animals of these regions are day forms.

In temperate regions also summer is the important season for most animals. In summer the day is longer than the night. The daytime community is likely, therefore, to be much larger than the nighttime one. In the deserts of our own Southwest, however, in spite of the fact that the summer day is longer than the summer night, one would not be likely to see any animals except perhaps a lizard or two during the hours when the hot, drying rays of the sun beat down. At night, when the air is cool and less drying, animals come out of caves, underground burrows, and hiding-places, and the desert comes to life. Bats chase insects on the wing, and owls and coyotes hunt kangaroo rats.

As we go farther and farther from the poles, the night communities become larger and larger. At the Equator, where day and night are each twelve hours long throughout the whole year, the night communities are even larger than the daytime ones. In the jungle during the day few animal sounds break the deep stillness. But at night a very bedlam breaks loose. The wild cries of animals disturb people's sleep.

Plants cannot hide during one period and come out again at another. But there is a day and night rhythm among the plants of a plant-animal community. Some plants close their flowers at night; others open their flowers at that time. The leaves of some plants droop at dusk. During the daytime some flowers turn to face the sun. The most important difference between the day activities and the night activities of plants cannot be seen. Green plants can make sugar only when the light is strong. At night the food which has been made during the daytime is carried down from the leaf factories to other parts of the plant.

Of course, you know that changes of season bring about changes in plant-animal communities. In arctic regions there are few of the plants that we know best, but there are many mosses and lichens. These plants carpet the ground everywhere and do not die down even in winter. All the other plants—dwarf trees and many kinds of grasses and flowers—grow only during the short summer season. But with plenty of water from melting snow and with twenty-four hours of sunlight every day for a time they make the most of the short season. All the flowers bloom at once.

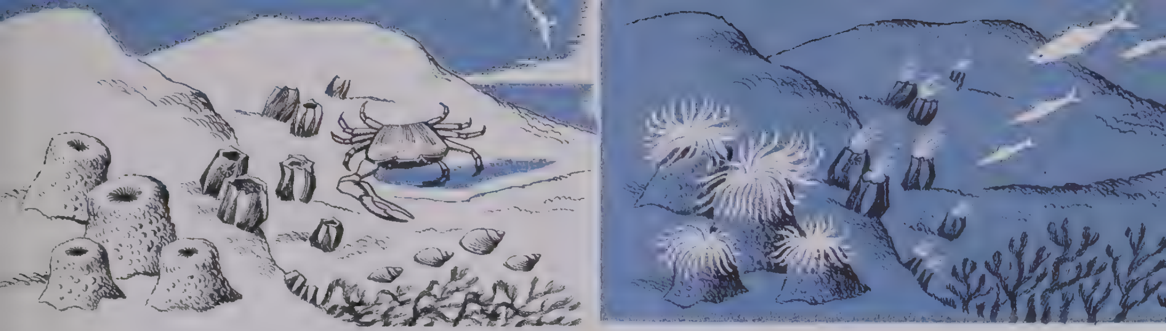
Feeding on the flowering plants there are bees, butterflies, mosquitoes, and many other insects. There are spiders and mites, too. These little animals are cold-blooded animals.

Their bodies are warm or cold according to the temperature of their surroundings. During the cold arctic winter these animals cannot move their muscles, much less run, fly, or feed. In the cold months the only active animals of the arctic regions are warm-blooded animals—animals which are able to keep the temperature of their bodies high the year round. Some of the warm-blooded animals migrate southward in the fall, but many of them stay through the long winter. The herbivores dig beneath the snow for mosses or lichens, or feed on branches and buds that stick out above the snow. The wolf kills reindeer, the snowy owl catches lemmings, little animals somewhat like rats, and the polar bear eats seals, fish, and seaweed.

The seasonal changes in temperate regions are somewhat like those of arctic regions. In a woods in Illinois, for example, there are some animals which may be found in the woods the year round. The blue jay, the red squirrel, and the white-footed mouse are among them. Wood snails, leaf bugs, and

olar Bear

Ylla from Rapho-Guillumette



leaf hoppers are present all the year round but are much more numerous at some times of the year than at others. Juncos are present in winter and early spring but not in summer and autumn. At the beginning of summer they go to cooler regions farther north. Spiders and many insects may be found in spring, summer, and early autumn, but not during very cold weather. Ground squirrels hibernate in cold weather even though they are warm-blooded.

In the tropics the temperatures are much the same throughout the year. Such seasonal changes as there are in the plant-animal communities are caused by changes in the amount of rainfall. Some animals of the tropics are much more active during the dry season. Some, on the other hand, are more active during the rainy season.

A special kind of rhythm is found among animals that live at the edge of the sea. Most of these animals are active only at high tide when they are covered with water. When the tide is out, they draw back into their shells or contract their bodies and remain quiet. The barnacles, sea anemones, and periwinkles, for example, are inactive except at high tide. On the other hand, many shore scavengers become active only at low tide. They find on the shore much dead plant and animal material left behind by the tide.

Let us stop now and be sure that we have the right picture of the plant-animal communities of the world before going on. The earth has belts of cold, temperate, and hot climates. Within each of these belts there are many, many plant-animal communities such as an oak woods or a grass prairie. A plant-animal community is no hit-or-miss affair. The members of the community are closely bound together. An animal of such a community does not attack any animal or

plant it happens to run across. Instead, the plants and animals of a community tend to fall into definite food-chains. All these chains interlock with one another to form a complicated food-web. Every plant or animal in the whole community is included in the food-web.

Although the various communities of the world differ in many ways, their general organization is the same. They all have green plants, herbivores, carnivores, parasites, and scavengers. The individuals that make up the community may come and go—some are eaten, others are killed by accident, and new ones are born. The activities in the community may differ greatly at different times of the day and the year. But through all the changes the plant and animal populations remain very much the same unless something comes along to upset the balance. The balance may be upset by an earthquake, a great flood, a drought, a hurricane, an epidemic of disease, or, worst of all, the unwise acts of man.

How Balance Is Brought About

Why do the numbers of plants and animals in a plant-animal community tend to stay about the same year after year? What you have found out about food-chains and parasite-chains will help you understand. Let us think of a grass-mice-fox food-chain. If grass is unusually abundant, the mice have plenty of food. With plenty of food they multiply faster than usual. But as they multiply they furnish more food for the foxes. Then the foxes multiply more rapidly than usual, more mice are eaten, and the number of mice is brought back to normal again. When a dry year occurs, there is less food for the mice. The mice then multiply less rapidly, and there is less food for the foxes. The foxes then multiply less rapidly and go down in number. The chart on the opposite page pictures the up and down swing.

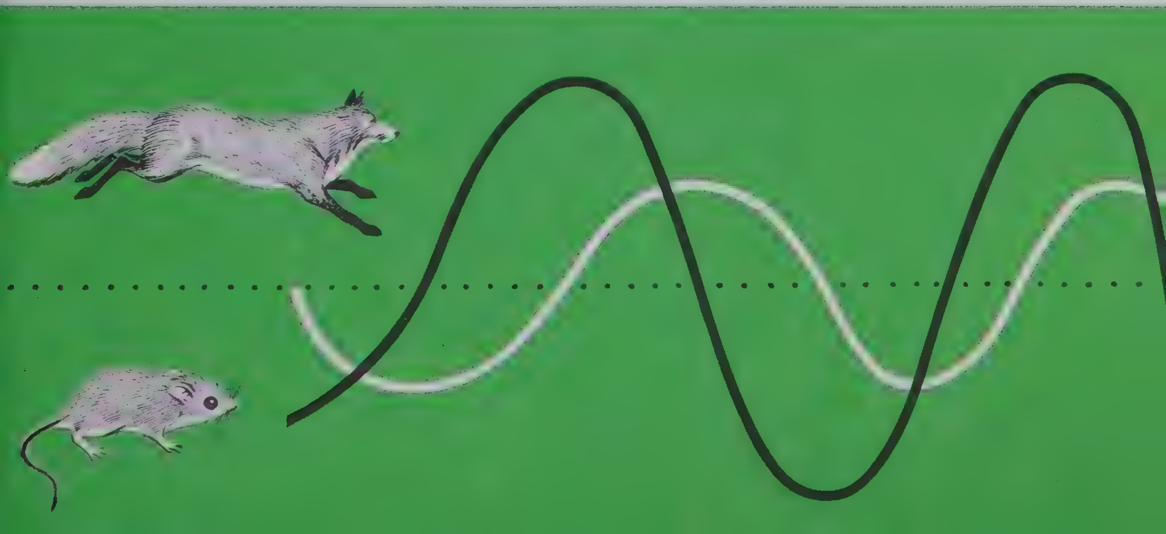
But why, you may wonder, before the number of foxes is normal again, do not the foxes eat up every last mouse? The answer is that, as soon as mice become so scarce that they

are hard to catch, foxes start eating some other kind of food. The red fox of Canada, for example, can eat either mice or rabbits. Whenever mice become scarce, the foxes hunt for rabbits. The mouse population has a chance to get back to normal. Soon rabbits may be hard to find, and the foxes begin to eat mice again.

In the illustration you have just read you have seen one way in which a top carnivore, even though it has no larger animal enemies, is kept down to normal numbers. When food is scarce, multiplication is less rapid.

Sometimes when the top carnivore in a chain gets above normal in number, it may leave the plant-animal community in which it lives and go to some other region. As you have been told, the snowy owl eats lemmings. When lemmings are very common, snowy owls increase. When lemmings become very scarce, as they sometimes do, the owls may migrate to find food. At times they come down from Canada into New England and New York by the thousands, killing small birds and rodents. But the region to which they have migrated finally comes back into balance again, because the owls cannot breed in their new home, and they die off.

Parasites are important in keeping animals down to normal numbers. If an animal of any kind becomes overcrowded, a disease caused by parasites is likely to spread and kill large numbers of that animal.




Emperor Penguin United Press

If animals increase too rapidly, they may even starve to death. But starvation is not the most common check on numbers. Usually something else cuts down the number of animals before they have a chance to starve.

In the case of top carnivores weather may be the only important check on numbers. The emperor penguin, for example, is a large bird which lives in the Antarctic. It feeds on fish and stands at the top of a food-pyramid that has as its base tiny plants of the sea. This penguin has no serious enemies. It has no epidemic diseases that we know of. But it has to contend with very low temperatures—temperatures as low as 70 degrees below zero. Many eggs that are laid fail to hatch, and many young birds die in the extreme cold. Penguins are often killed, moreover, by avalanches of snow. The number of penguins, year in and year out, remains about the same.

Unbalance in Nature

Unbalance in nature cannot always be blamed on people or on great catastrophes such as storms and floods. *Plagues* of animals sometimes occur which are not easy to explain.

Let us see first something about the rates at which animals might increase if there were nothing to check them. The female cod lays millions of eggs at a time. If all the codfish eggs laid grew to be full-grown fish, the oceans would soon be full of cod. A housefly lays more than a hundred eggs at a time. It takes only about two weeks for an egg to develop into a full-grown housefly. In a single season, if all the eggs that were laid hatched and if none of the flies died, the descendants of a single pair of houseflies would number more than 14,000,000,000,000,000,000. If all the houseflies on earth

multiplied at this rate, there would soon be no room on the earth for anything but houseflies.

It is absurd to think of the oceans filled with cod or of the land covered solidly with flies, but there are many animals which often do, for a short time, multiply very, very rapidly. Then the so-called plagues of these animals occur. You have probably heard of plagues of grasshoppers and of rats. There may be plagues of other animals, too. Any plague means that the balance in a plant-animal community has been greatly upset. When a plague occurs, the animals which have multiplied so rapidly may migrate to new places. Perhaps instead an epidemic of disease ends the plague.

Cornfield Ruined by Grasshoppers *United Press*

No plagues are more interesting than the plagues of lemmings. The lemming is one of the most important herbivores of the arctic tundras. It forms the chief food of the snowy owl, the arctic fox, and the arctic wolf. Every few years the lemming increases very greatly in numbers and then migrates.

The best records of lemmings are those of the Norwegian lemmings. These lemmings live not only on the tundras of the Far North but also on the tops of mountains in southern Norway and Sweden. Every few years the lemmings from the mountains migrate down into the lowlands in enormous droves. They move chiefly at night. Traveling in rows about three feet apart, they go without pause over cliffs and through rivers. They even gnaw their way through haystacks that are in their line of march. They travel on and on—perhaps for as much as a hundred miles—until they reach the sea. Into the sea they plunge and swim on until they die. As the lemmings migrate, they eat all the small plants in their path. They are followed by wolves and foxes.

A century ago lemming years in Norway were only two or three years apart. Now they are usually four years apart. Immediately after a lemming year lemmings are scarce, but they increase so fast in spite of their animal enemies that within a few years they are overcrowded again.

Immense droves of migrating rats are well known in Europe and Asia. And there is at least one record of migrating squirrels. In 1819 an army of gray squirrels swam across the Ohio River about a hundred miles below Cincinnati.

Why do some animals suddenly get out of control and multiply until they are a plague? In some cases we have no good clues. In almost every case in which we do have a clue the plague can be traced to some change in the weather.

In the tropics, where there is little change in the weather, animal numbers change very little. There are almost never any serious plagues. On the other hand, there are such regions as the western plains of the United States and Canada where the only thing certain about the weather is that it will be uncertain. The summers are often very hot, and the winter temperatures may go down to 50 or 60 degrees below zero. Some years have a fair amount of rain, but these may be followed by five or six years of drought. Such places are the scenes of all kinds of animal plagues. The various checks that act to keep a plant-animal community in balance cannot keep up with the suddenness of the weather changes.

In Nevada in 1907 field mice increased so fast that the ground was riddled with holes for miles, and 15,000 out of 20,000 acres of alfalfa were destroyed by the mice. Usually mice are held in check by the carnivores that eat them, but when something in the environment causes a sudden plague of mice, their enemies cannot keep up with them. The animals that feed on mice begin to increase, but they are larger and slower-growing than mice and cannot increase fast enough to keep up with the increase in the number of mice. It may take two or three years or longer for them to catch up with their small prey. In the Nevada mouse plague about 3,000

carnivores ate over a million mice a month without changing the number of mice enough to be noticed.

But, even when there are plagues, sooner or later a plant-animal community, if it is left alone, comes back into balance. Let us think, then, of a community as a pair of scales which stays in balance as long as nonliving factors remain the same and we do not interfere. Now if we give one pan a sudden push to stand for a sharp change in weather, the pans will move rapidly up and down. At last, however, if left alone the pans will again come to rest in a balanced position.

Unbalance Caused by Man

Some of the ways in which man has upset the balance in nature have already been mentioned. Among these ways are planting crops, shooting birds which feed on insect pests, and draining swamps where birds nest. Sometimes the bad results of such foolish acts are not seen till long afterward. The pioneers who killed most of the beavers of our western streams did not foresee that they were removing one check to floods. Partly because of the killing of the beavers, floods in the West are more common than they once were.

Beaver Dam, a Natural Flood Check

Willis Peterson from Gamma

Man does not always make animal populations smaller; sometimes he tips the balance of life in the other direction. The cockroach is much more common than it was before people crowded together into cities. It is now often easy for cockroaches, if they cannot find food in one kitchen, to reach another close by. The black widow spider is becoming more and more common. Perhaps this poisonous spider is increasing in number because the number of houses is growing and the spider multiplies faster in damp basements, out of reach of its enemies, than it does out of doors.

Even when man tries to increase the numbers of animals he likes, he may cause trouble. Early comers to the forest on the north rim of the Grand Canyon were much impressed by the big herds of deer in the forest. For many years both the settlers and the forest rangers went to great pains to kill the mountain lions that preyed on the deer. The deer multiplied so fast that soon they destroyed their favorite food, the cliff rose. They were forced to eat spruce, pine, sage, and even grass. At last there was so little food for the deer to eat that many of them died. Their skeletons can still be seen in many places in the forest.

Man's attempts to control the animals that threaten his crops and his domestic animals are full of blunders. Some of these blunders have done great harm to our wild life without helping either our crops or our domestic animals. In fact, every year farmers and hunters carry on campaigns that are very foolish—campaigns such as this: First the farmers pay cash awards (or get the government to do so) for the killing of hawks and coyotes because these animals once in a while steal a chicken. As hawks and coyotes become fewer, the jack rabbits on which they feed get out of control and begin to do great damage to crops. Then a campaign against jack rabbits begins, and soon there are few jack rabbits. Now hawks and coyotes cannot find enough jack rabbits to eat, and they are driven more and more to taking chickens, whereupon the cash awards for killing hawks and coyotes are raised.

Why do not the farmers simply let things alone? Most

gue of Jack Rabbits in Australia

Dunstan from Black Star

farmers do not know enough about food-chains and balance in nature to understand that they are bringing most of their troubles with hawks, coyotes, and jack rabbits on themselves. When they see their chickens being stolen, they do not look ahead to see what harm shooting the hawks and coyotes may do. Besides, some of the companies that make guns and ammunition urge the shooting of such animals as hawks and coyotes. They want to sell more guns and ammunition.

Men have often upset the balance in nature by bringing into a region plants and animals that had never been there before. Some of these plants and animals have been introduced purposely; some have been introduced by accident.

Nearly a hundred years ago the farmers of our South wanted a kind of grass that would make good pastures. Johnson grass was brought in from Turkey. It grew very well—far too well. Now it is a troublesome weed. The starling was brought into this country by someone who liked it in its native region. Now it is driving out native birds.

Many such stories can be told of Australia. Australia, it is believed, was once joined to Asia and South America by land bridges. By the time the first white settlers reached Australia,

however, it had been separated from all the other continents for millions of years. Many of its plants and animals were very different from the plants and animals found in other parts of the world. The balance of life in Australia was greatly upset by some of the plants and animals the settlers introduced. The prickly-pear cactus was taken to Australia in pots to brighten the homes of the settlers. Soon it was growing wild. It spread so fast that before long it had covered thousands of acres. The rabbit was taken to Australia as a domestic animal. Soon there were so many rabbits that it was hard for the farmers to raise any crops.

Many of our most serious insect pests were brought to our country from other lands by accident. Among these insect pests from foreign lands are the Japanese beetle, the gypsy moth, and the cotton boll weevil.

It is not hard to understand why foreign plants and animals brought into a region often become pests. In their new homes they have no natural enemies to hold them in check.

Man's Attempts to Control Unbalance

After people have upset the balance in nature, they have often tried to undo some of the harm they have done. Most attempts have failed, but a few have succeeded.

You have already been told that, after the prickly-pear cactus was introduced into Australia, it soon became a very troublesome weed. In 1920 scientists found a caterpillar which bores holes in the cactus, a bug which sucks the juice of the cactus, and a mite which nibbles the surface of the plant. These three animals were introduced into Australia. Now the cactus is under control.

Prickly-Pear Cactus Josef Muench

In the Fiji Islands the coconut palm has an enemy—the purple-winged coconut moth. In 1922 this

moth spread to several islands, and the million-dollar coconut crop of the Fiji Islands was in danger. A search began for an enemy of the moth. In another part of the world a fly was found which was a parasite of a moth related to the purple-winged coconut moth. Three hundred flies of this kind were shipped to the Fiji Islands in 1925. A year later 30,000 flies were raised and let loose. They attacked the purple-winged coconut moths at once. Later two other parasites of the moth were introduced into the Fiji Islands. Soon the moth became rare.

Introducing an enemy is the best kind of control of a new weed or a new animal pest, for it is most like the checks found in nature. Such methods as shooting and spreading poison get rid of many pests, but they may do much damage. The poisons we spray on apple trees to kill insect pests also kill bees. Bees are needed to carry pollen from flower to flower. If all the bees were killed, there would be no apples.

But natural controls are hard to find, and they should be tried only on the advice of trained scientists. Otherwise the control itself may get out of hand and do more damage than the pest. To control the rats, mongooses were introduced into some of the West Indies. The rats rapidly grew scarce. Then the mongooses began to eat poultry and wild birds and were soon almost as bad a pest as the rats had been.

Mongoose

New York Zoological Society Photo

Conclusion

No one yet knows very much about food-chains, parasite-chains, and the causes of animal plagues, although these things are very important. We know much less about them, for example, than we know about the stars. But we know a thousand times more than we are putting into practice. We have made and are still making some serious mistakes.

The interests of people cannot help but clash with the "interests" of certain plants and animals. To feed ourselves, we must clear away forests and raise crops even if in doing so we upset the balance in nature. With the growth of our country, it was necessary to drive the bison out of the rich Mississippi Valley so that we could farm the land. But we could well have left the bison parts of the western plains which were never suitable for agriculture and which are easily turned into useless dust bowls.

Seeing the results of some of our mistakes should make us very careful about interfering with the balance in nature. Before we do anything that may seriously upset it, we should ask the advice of scientists. If we are willing to follow their advice, we may save the rich natural resources of plant and animal life which still remain in our country.

See for Yourself

1. Try to find out, by watching, what niche some animal fills in a plant-animal community.

2. Try to work out for yourself some food-chain in your environment.

3. Examine with a microscope some of the green scum which forms on the walls of an aquarium. The scum is made up of very tiny green plants. Such plants form the first link in many food-chains.

4. Make a list of ten kinds of animals common in your region. By watching them, try to find out whether they are carnivores, herbivores, or omnivores. Check your conclusions by using reference books.

Litho. in U.S.A.